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14. ABSTRACT

The objectives of this work are to quantification of ocean sound speed space-time scales due to internal waves, mesoscale eddies, internal tides, and other fine structures through the analysis of an extensive oceanographic data set collected during North Pacific Acoustic Laboratory (NPAL) field year between summer 1998 and summer 1999, and establish the connections between oceanic and acoustic variability.

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An analysis of upper ocean sound speed variability and its effects on long-range acoustic fluctuations observed for the North Pacific Acoustic Laboratory

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LONG-TERM GOALS

Our long-term objectives are to understand the predictability limits of long-range acoustic transmissions, and delineate the important environmental factors contributing to predictability.

OBJECTIVES

The objectives of this work are to quantification of ocean sound speed space-time scales due to internal waves, mesoscale eddies, internal tides, and other fine structures through the analysis of an extensive oceanographic data set collected during North Pacific Acoustic Laboratory (NPAL) field year between summer 1998 and summer 1999, and establish the connections between oceanic and acoustic variability.

RESULTS

The analysis of the upper ocean sound speed structure is broken into two frequency bands where mesoscale/internal wave bands have frequencies below/above the local inertial frequency. The mesoscale band has rms sound variations of order 3 m/s rms in the upper ocean and 1m/s rms at depth, whereas the internal wave band has rms variations of 1 m/s in the upper ocean and 0.3 m/s at depth.

The sound speed variance from the internal tide (M_2 tide) is estimated. This variance is further divided into the M_2 tide deterministic component and the M_2 tide random component. The variability is dominated by the deterministic tide of the M_2 peak energy, but compared to the total internal wave band energy the M_2 energy is quite small, which is less than 15% contribution of total internal wave band.

The mesoscale frequency spectrum has an ω^{-2} form with very little depth dependence. The internal wave frequency spectrum shows a GM-like continuum (i.e. ω^{-2} form) between the semidiurnal tide frequency and the buoyancy frequency, a strong semidiurnal tide line (plus second harmonic) and a gentle rise in energy near the buoyancy frequency. These spectral shapes are only a function of depth to the extent that the buoyancy frequency cut off changes with depth. The spectral levels (and the tide lines) do vary with season with most energy occurring in the winter and spring seasons. Seasonal sensitivity diminishes with depth. Two-dimensional spectra (k_z, ω) show near factorization across all frequencies. Vertical wavenumber spectra from both moored instruments and XBT surveys show a GM-like k_z^{-2} but the spectrum shows a cut off at 0.1 – 0.3 cpm. Horizontal wavenumber spectra from the XBT surveys show a non-GM behavior of $k_x^{-1.5}$.

Statistics of the vertical shear of horizontal currents (du/dz, and dv/dz) show large values beneath the mixed layer; shear scatters sound the same way that sound speed gradients (dc/dz) do. While internal wave induced sound speed gradients dominate in the upper ocean, the shear effect is only less by a factor of 2-5.

IMPACT/APPLICATION

The results from the study of in situ environmental data provide significant quantification of space-time scales of ocean sound speed variability in both internal wave and mesoscale frequency bands. All those results impose hard bounds on the strength of sound speed fluctuations one might expect in the region of the North Pacific for both internal-wave band fluctuations and mesoscale band fluctuations. Moreover, the analysis shows several differences between real ocean sound speed fluctuations and those modeled using the GM spectrum, and in particular the effect of shear may play an important role.

PUBLICATION RESULTING FROM THIS PROJECT

In Preparation:

J. Xu and J. Colosi, " Observations of deep water, upper ocean sound speed structure and shear in the Eastern North Pacific Ocean", J. Acoust. Soc. Am.